IMPROVE and IMPROVE Protocol Technical System Audits Course

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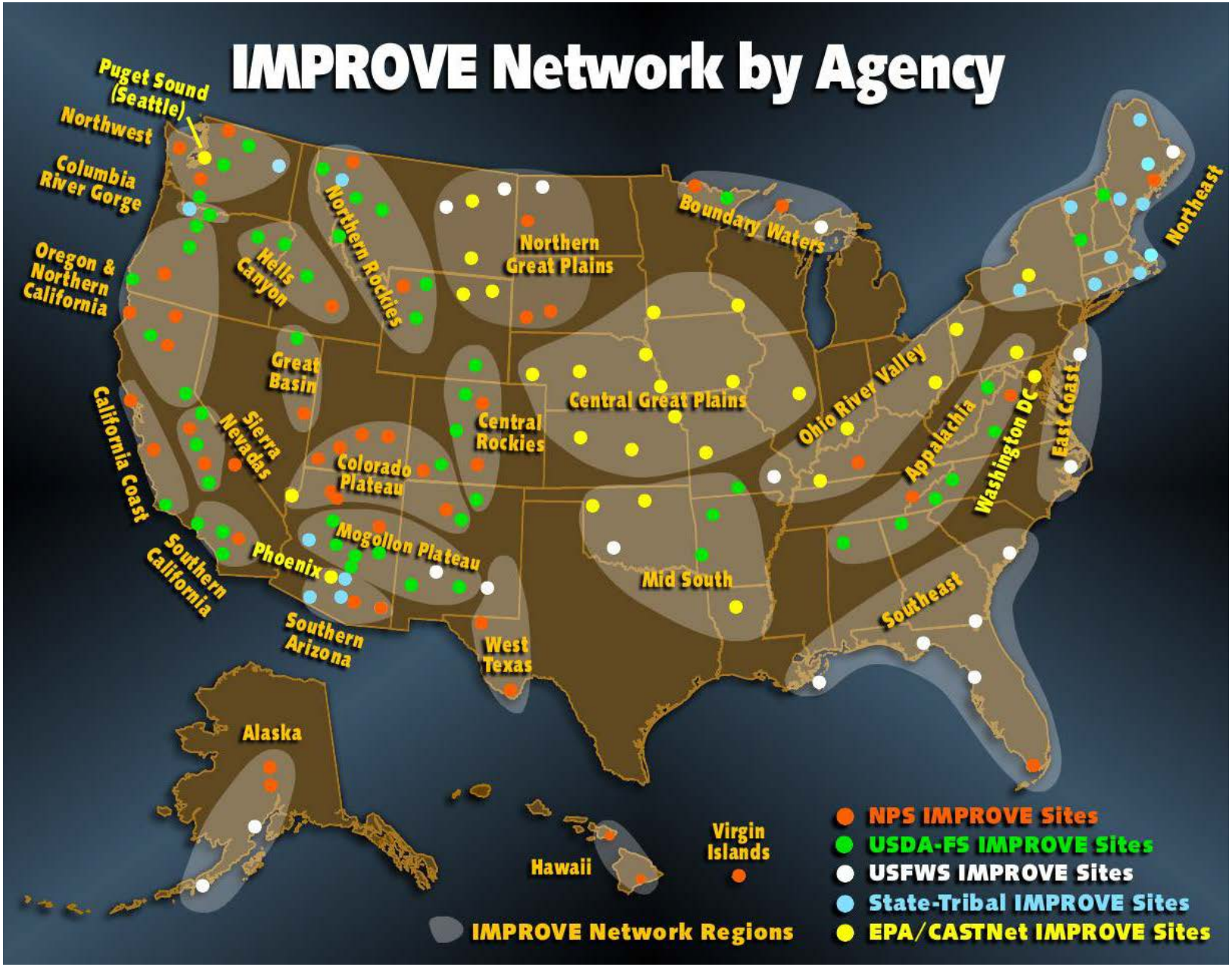
Course Objectives

1. Understand key concepts of the IMPROVE sampling system and aerosol monitoring network
   - Why monitor?
   - How are the data used?
2. Understand key steps for conducting a Technical Systems Audit (TSA)
   - Prepare for the audit
   - Conduct the audit
   - Finish the paperwork

Purpose of IMPROVE monitoring

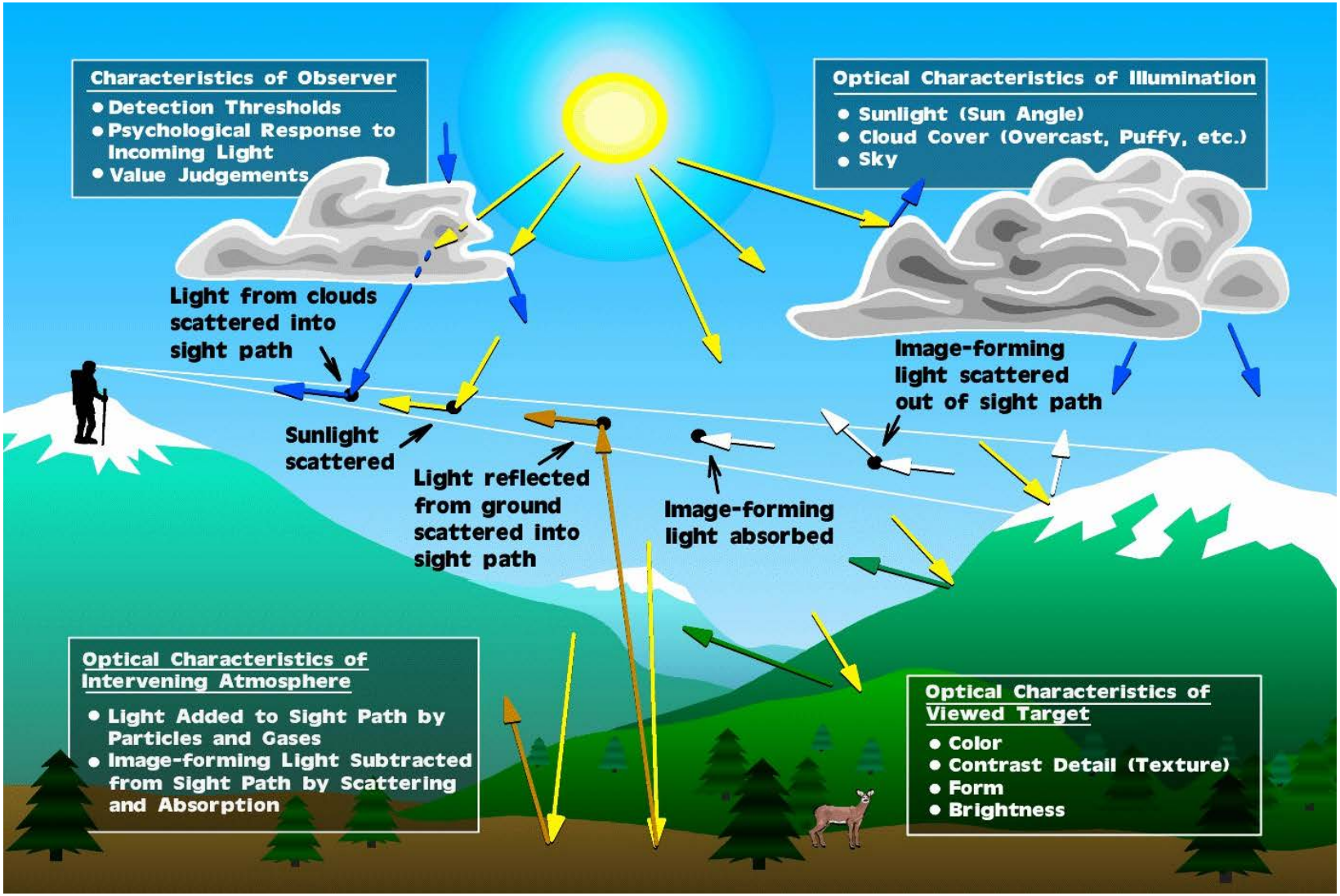
- Goal: is to meet the monitoring requirements associated with the visibility protection provisions of the Clean Air Act
- Monitoring is required to determine visibility levels, track impairment trends, and to develop source attribution relationships
- 1999 Regional Haze Rule requires monitoring for establishing current conditions (2000-2004) and tracking progress toward meeting RHR


IMPROVE Network by Agency
Puget Sound (Seattle)
Northwest
Columbia River Gorge
Oregon & Northern California
Hells Canyon
Northern Rockies
Northern Great Plains
Boundary Waters
Northeast
Great Basin
California Coast
Sierra Nevadas
Central Rockies
Central Great Plains
Ohio River Valley
Appalachia
Washington DC
East Coast
Colorado Plateau
Mogollon Plateau
Phoenix
Southern California
Southern Arizona
West Texas
Mid South
Southeast
Alaska
Hawaii
Virgin Islands
IMPROVE Network Regions
NPS IMPROVE Sites
USDA-FS IMPROVE Sites
USFWS IMPROVE Sites
State-Tribal IMPROVE Sites
EPA/CASTNet IMPROVE Sites

IMPROVE Program

- Establishes current visibility and aerosol conditions in mandatory Class I areas
- Identifies chemical species and emission sources responsible for existing man-made visibility impairment
- Documents long-term trends in visibility
- Provides regional haze monitoring representing all visibility-protected federal Class I areas, where practical.

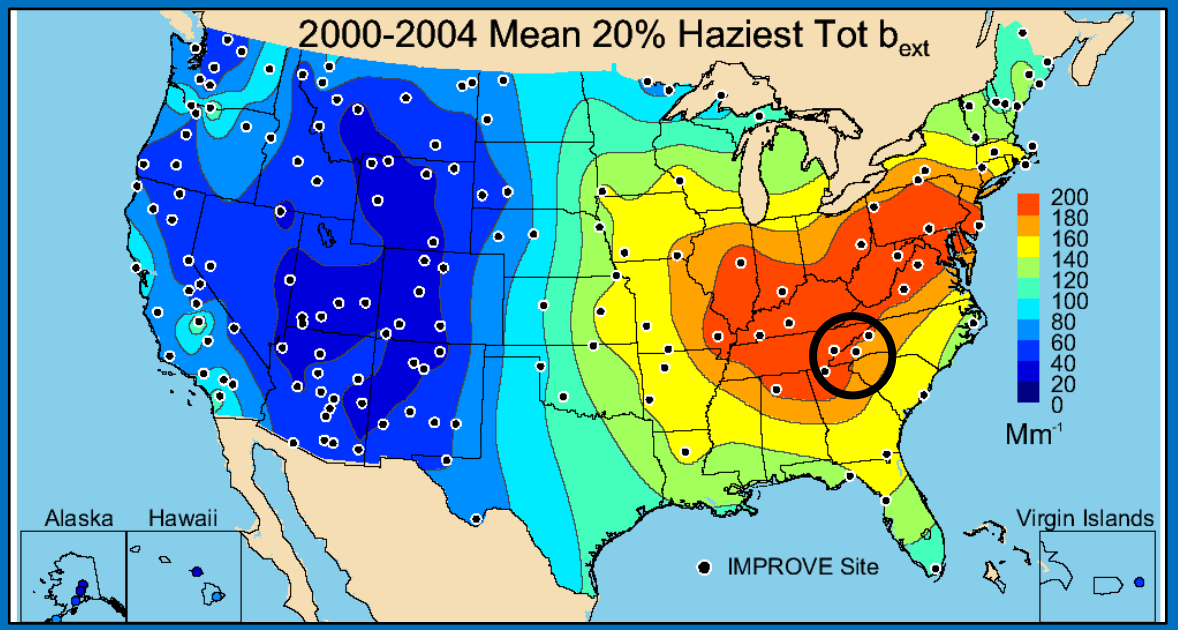
Light Attenuation in the Atmosphere



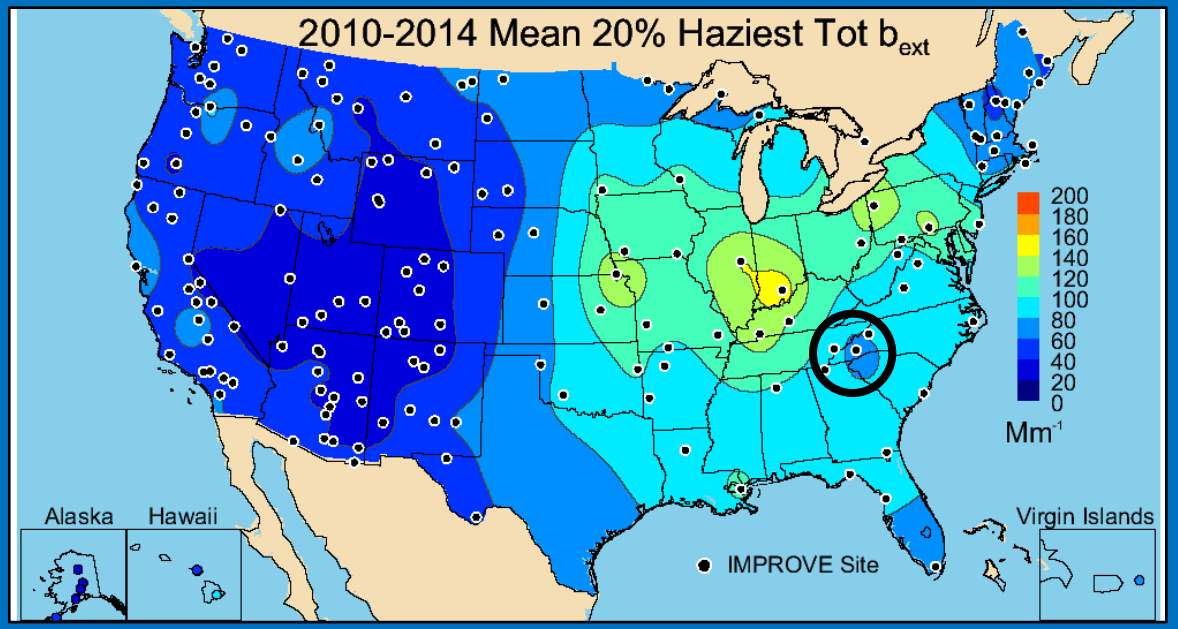
$$b_{ext,p} \approx eff*f(RH)*[\text{sulfate}] + eff*f(RH)*[\text{nitrate}] + eff*[\text{OC}] + eff*[\text{Soil}] + eff*[\text{EC}] + eff*f(RH)*[\text{NaCl}] + eff*[\text{CM}]$$

Visibility Degradation: Haziest b_{ext}

2000-2004



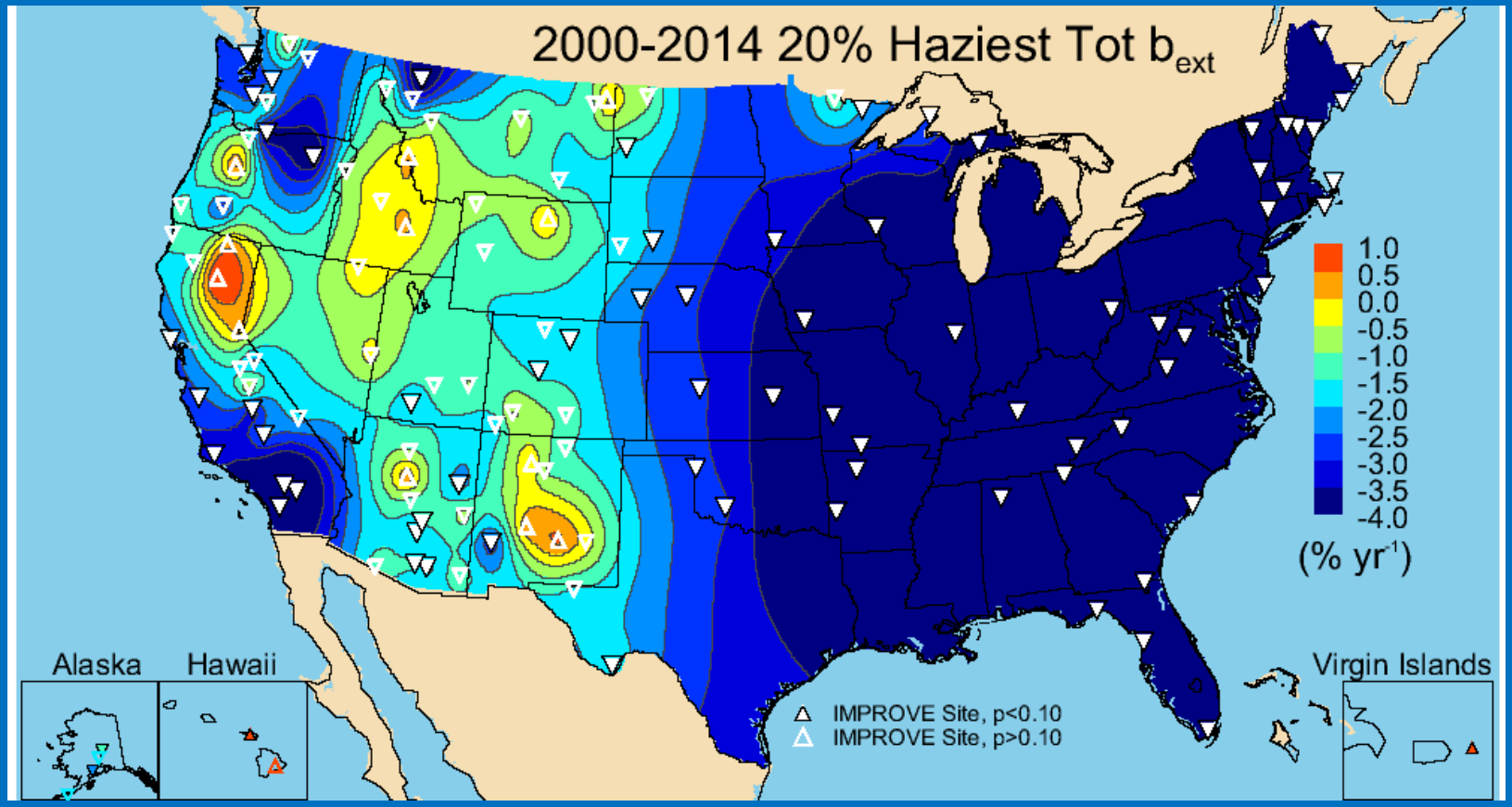
2010-2014



Great Smoky Mountains National Park Haziest Days

Trends in Visibility (Haziest b_{ext})

(2000-2014)



East: 77% reduction

West Coast: 28% reduction

Intermountain/Southwest: 18% reduction

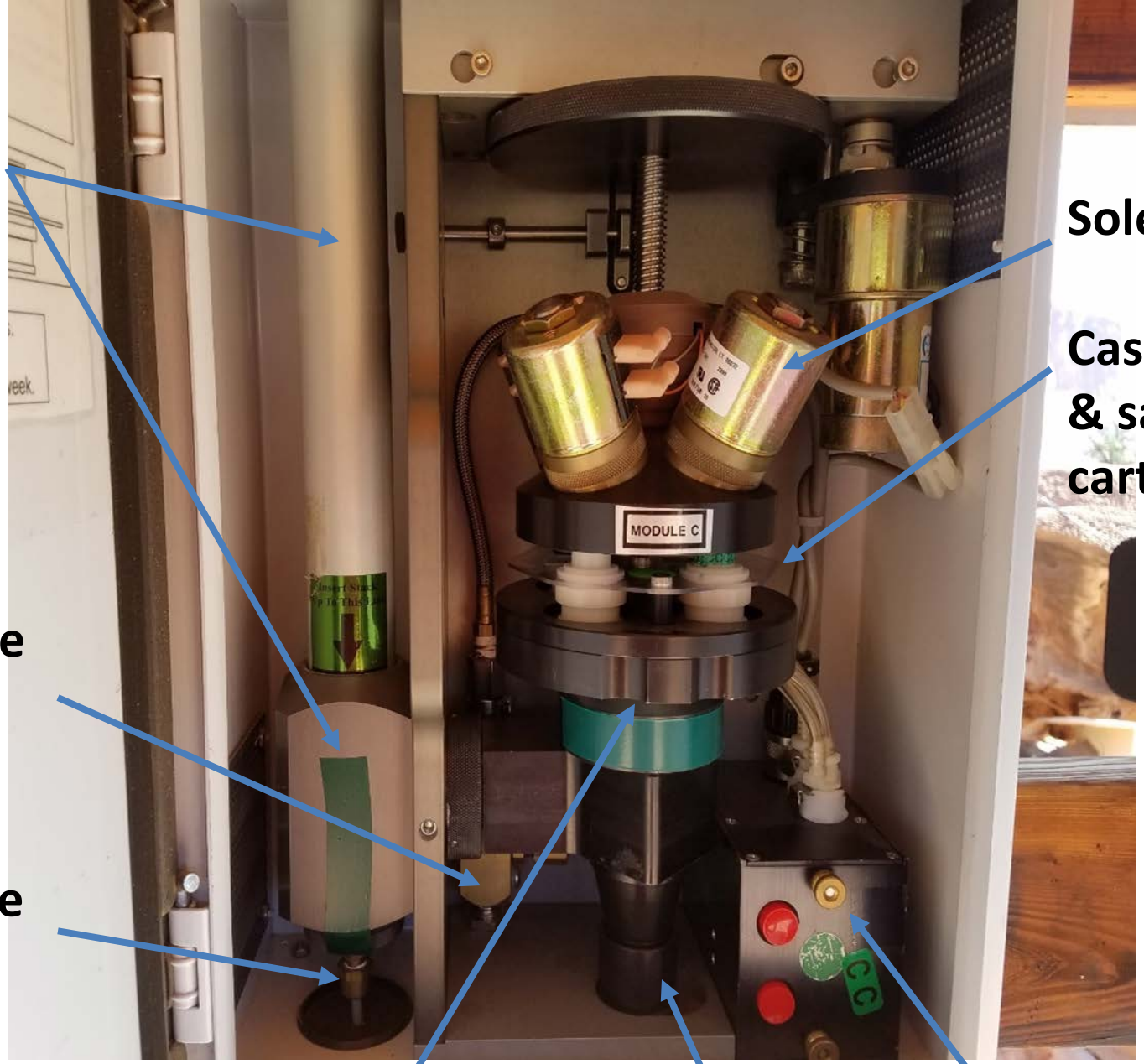
IMPROVE Data have been used in hundreds of journal articles:

- Spatial and temporal trends analyses
- Model comparison and verification
- Source attribution and aerosol transport assessments
- Identification and quantification of chemical species responsible for regional haze
- International aerosol transport
- Instrument/sampler intercomparisons

IMPROVE Sampler

IMPROVE Aerosol Monitoring Approach and Sampler Overview

- 24-hour collection period
- Sample collection is every third day
- Filter changes occur every Tuesday
- Four separate aerosol collection channels with one control module
  1. Channel A: teflon filter; gravimetric $PM_{2.5}$ mass, elements by XRF
  2. Channel B: nylasorb filter; ions by IC, (HNO_3) denuder
  3. Channel C: quartz fiber filter; TOR analyses for carbon (EC and OC)
  4. Channel D: teflon filter; gravimetric PM_{10} mass
- Aerosol size selection
  1. $PM_{2.5}$ cyclone for channels A-C; nominal flow rate of 22.8 lpm
  2. PM_{10} inlet with impactor for channel D; nominal flow rate of 16.9 lpm



PM 2.5
Inlet stack
& tee

Solenoids

Cassette
& sample
cartridges

Needle valve
& critical
orifice

Temperature
probe

2.5 micron Cyclone and dust cap

E-box pressure
transducers


PM10 Module
Inlet stack
E-Box
pressure
transducer
Cassette &
sample
cartridges
Solenoid
Needle valve
Flow control
DD
MODULE D

General Overview of Technical System Audits (TSAs)

Assess whether sampling site is in compliance with IMPROVE QAPP

1. Site meets sampling criteria
2. Integrity/condition of sampling structure
3. Measures flow rates, temperature, pressure using NIST certified audit device (tetraCal)
4. Observes operator technique (when possible) assess issues of sample contamination

1. Site Sampling Criteria

- Details in SOP 126 (IMPROVE website)
- Want to sample regionally representative aerosols (avoid local sources or particle loss)
- Conditions can change from site installation to present (road/land usage, vegetation)
- Note any problems/changes in the notes section of the TSA workbook
- Must have unrestricted air flow to the sample inlet in an arc of 270 degrees (preferably 360)

Siting Criteria

Removed from local sources

Automotive

vehicle usage distance between road and sampler

<10,000 vehicles per day	>25m between road and sampler
10,000-20,000 vehicles per day	>50m between road and sampler
20,000-40,000 vehicles per day	>75m between road and sampler
>40,000 vehicles per day	>100m between road and sampler

Combustion

Avoid areas influenced by diesel generator emissions, wood smoke, or incinerators.

Dust

≥400m from a large potential source of dust: landfill, agricultural operations, or an unpaved road with more than 400 cars per day.

Siting Criteria

a) 

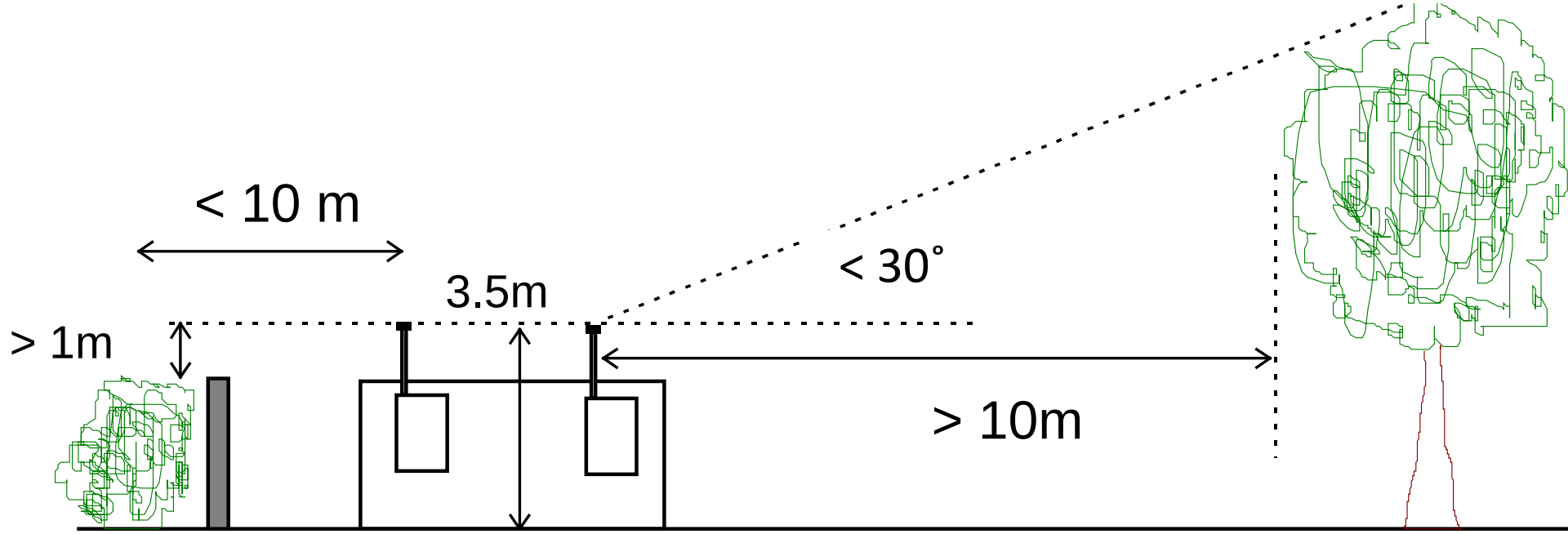
b) 

c) 

IMPROVE samplers are typically mounted in one of 3 configurations:

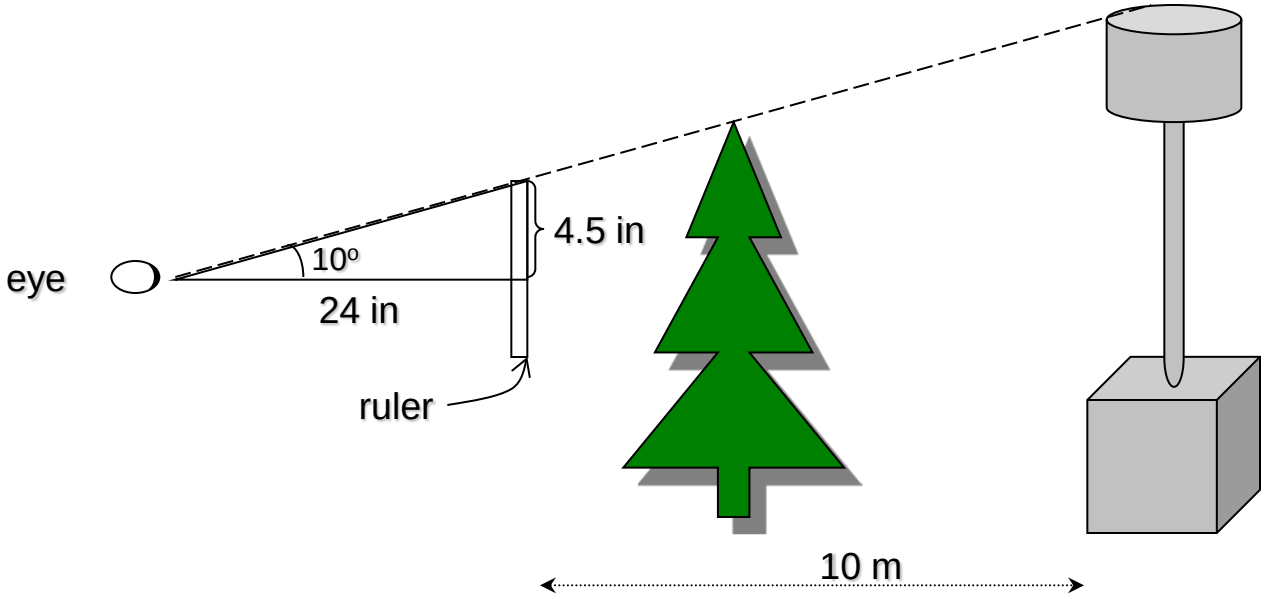
a. in an ambient temperature shelter (not heated or air conditioned)
b. outside, on the side of an existing shelter or building
c. outside, on a rack built expressly for the IMPROVE sampler

Schematic of location with respect to trees and solid barriers



IMPROVE Siting Criteria (Cont'd)

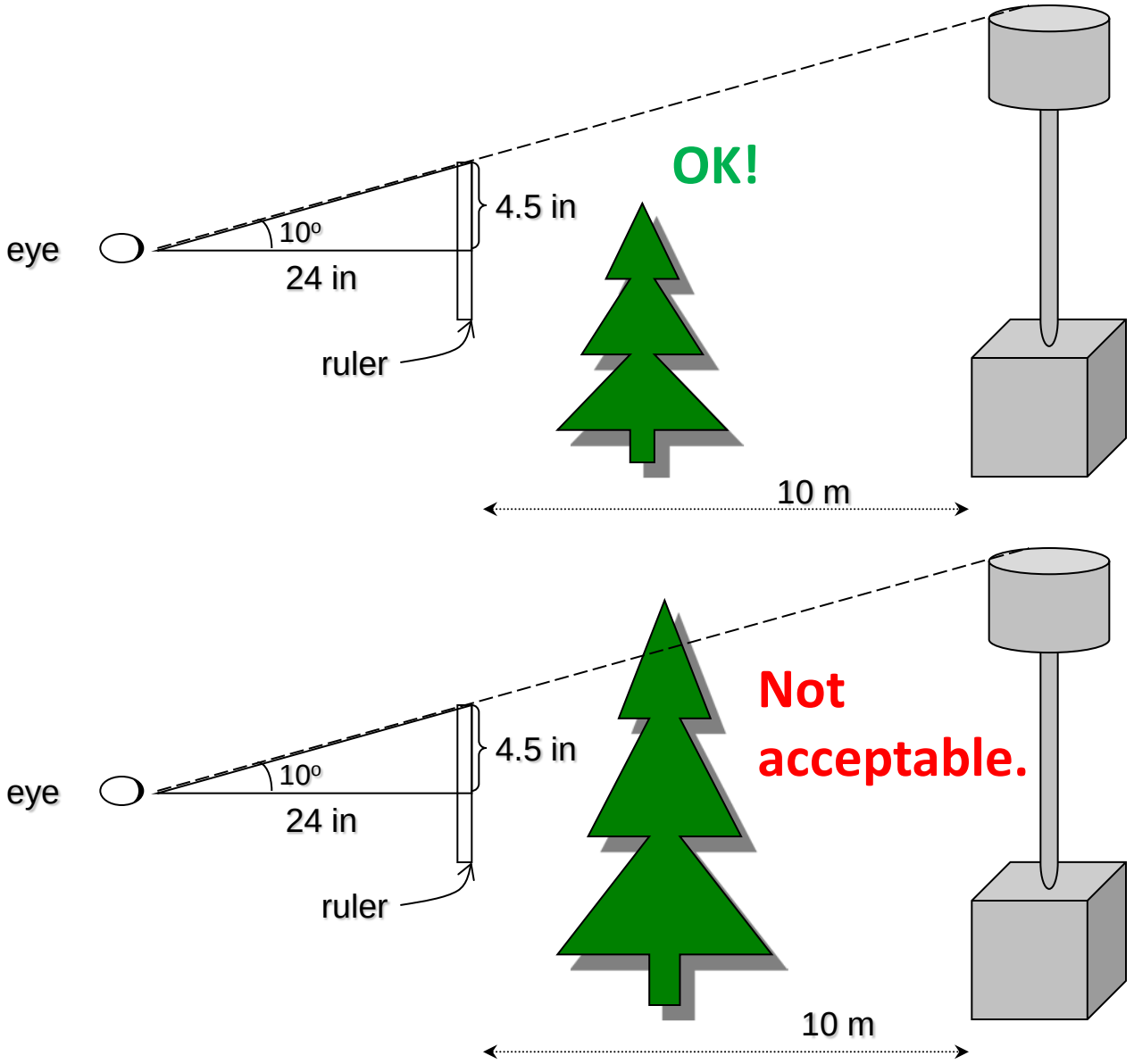
- <u>Within 10 m of the sampler</u>
  - A solid barrier (any object that would obstruct flow) should be at least 1 m below the inlet.
  - The top of the object must be lower than a 10° cone surrounding the sampler.



IMPROVE Siting Criteria (Cont'd)

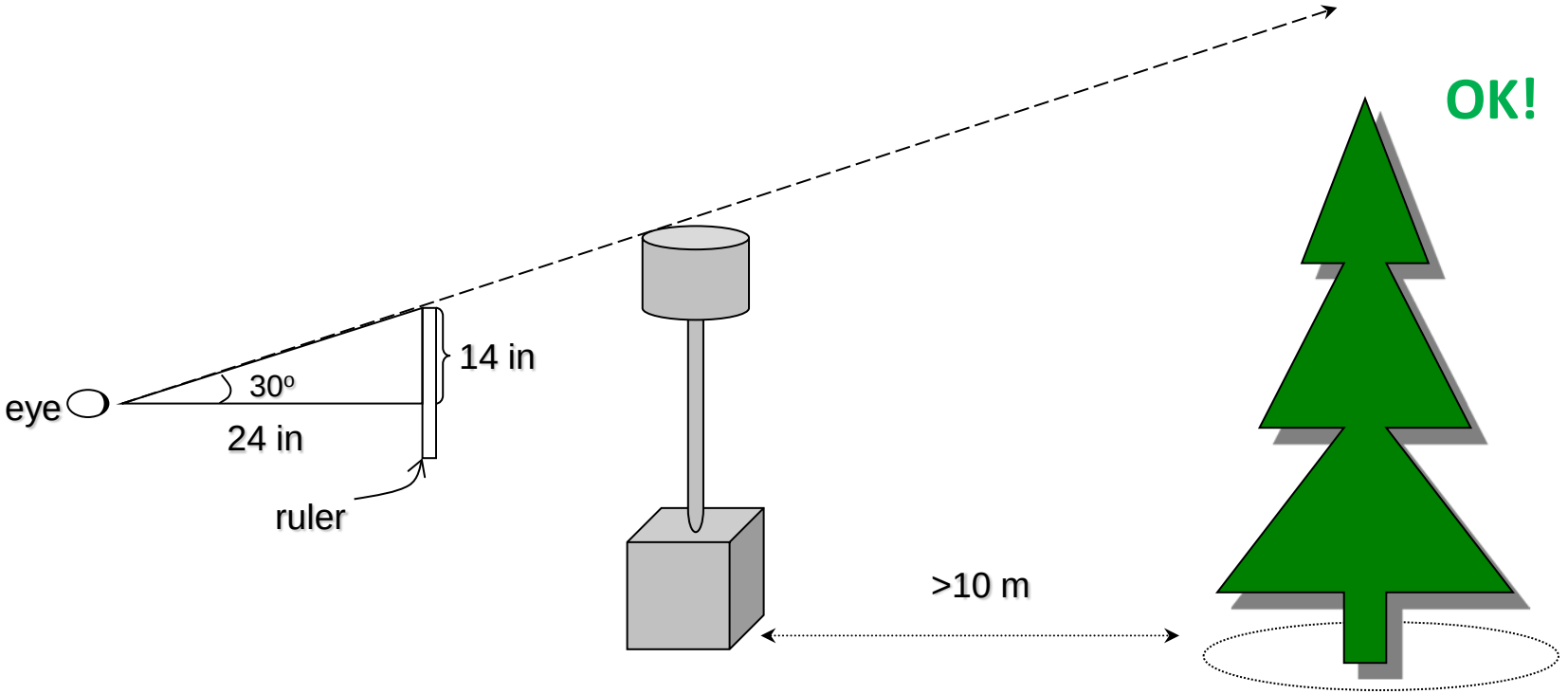
Within 10 m

Example: Hold a ruler at arm's length (~24 in) with the end of the ruler 4½ in above eye level. Move back from the sampler until the top of the ruler is in line with the top of the IMPROVE sampler. If the top of the solid barrier is lower than this, it is acceptable.



IMPROVE Siting Criteria (Cont'd)

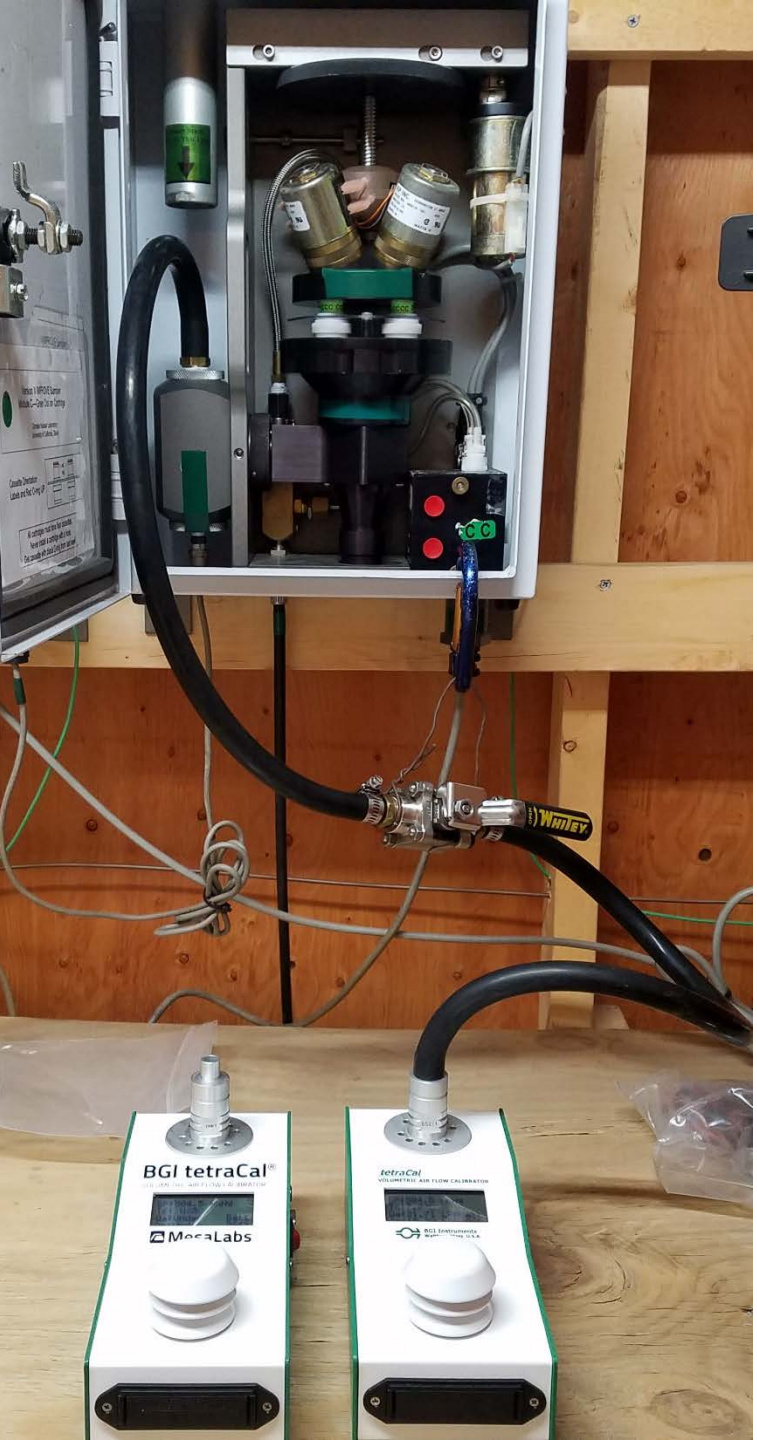
- <u>Beyond 10 m of the sampler</u>
  - The solid barriers or trees should not be higher than 30° above the horizontal with respect to the inlet.
  - Example: Using a similar approach, but from the opposite side of the solid barrier, 30° corresponds to a height of ~14 in.



2. Integrity of Sampling Structure:

1. Operator safety
2. Sample changes
3. Inlet integrity
4. Cleanliness of site (Bird nests. Mouse poop. Spider webs.)
5. Electricity (wiring)

Issues are to be documented in notes section of TSA and photos should be taken



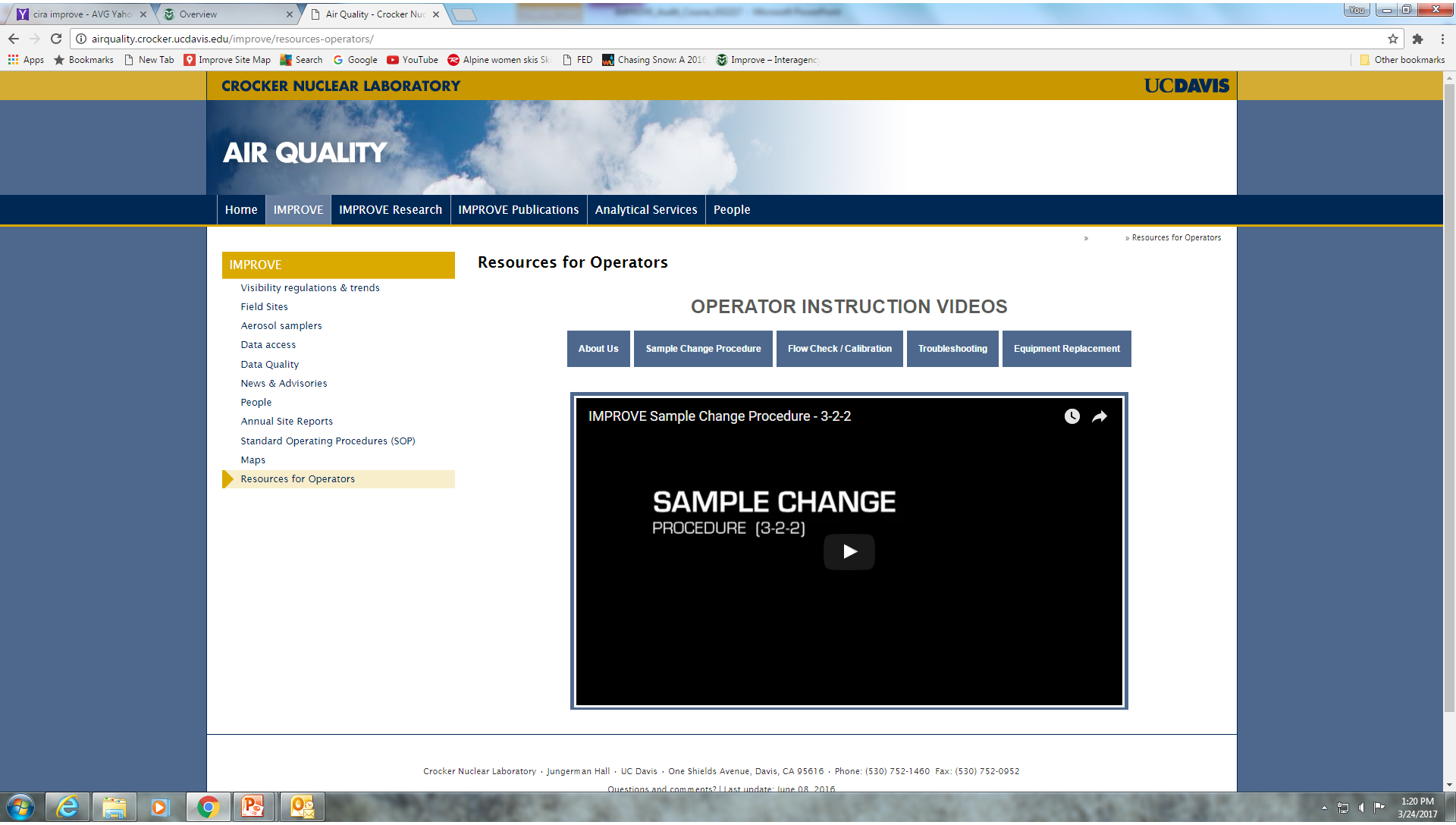
3. Measurements:

- Measure pressure, temperature, and the flow rate of each module using a NIST certified standard and compare with the IMPROVE sampler temperature & flow rate.
- Measure the vacuum pressure to ensure pump and sampler integrity for each module.
- Check date and time.

4. Observe site operator technique (if auditing on a Tuesday)

- Changing filters
- Sample handling technique to minimize sample contamination

Some operators are highly knowledgeable and have been working with IMPROVE for a long time; others not so much.



http://airquality.crocker.ucdavis.edu/improve/resources-operators/

Conducting the Audit
Getting started

1. Contact UC Davis: sampler calibration parameters; site logistics page; site operator contacts

   Yongjing Zhao: yjzhao@ucdavis.edu

2. Fill out TSA workbook and email to operators

   Four parts to the TSA workbook

   - Operator Form
   - Field Form
   - Summary Form
   - Field Form II

3. Contact operator. Set up meeting time/place and discuss access issues

Part 1 - Technical System Audit Form

Monitoring Site Location:					
IMPROVE Site ID:					
Latitude/Longitude from IMPROVE Website		Lat.:		Long:	
Assessor Name:		Affiliation			
Observer(s) Name:		Affiliation			
Assessment Date:					

Section 1. Organization and Responsibilities

1. UCDavis Field Operations Manager

Name:	Yongjing Zhao	Affiliation:	UC Davis
Phone:	530-752-1123		
Address:	One Shields Avenue		
	Davis, CA		
E-mail:	yjzhao@ucdavis.edu		

2. Monitoring Site Operator(s)

Name:		Affiliation:	
Phone:			
Address:			
Cell Phone:			
E-mail:			
Name:		Affiliation:	
Phone:			
Address:			
Cell Phone:			
E-mail:			

3. Date UC Davis field service technicians last visited the site for maintenace/calibrations:

(O = Other)

	RESPONSE		
	Y	N	O
4. Were site operators able to meet with UCDavis technicians during the site visit?			
5. Are site operators familiar with SOP 201 "IMPROVE Standard Operating Procedure for Sampler Maitenance by site operators"?			
6. Are site operators aware of resoucres intended to inform them about sampler operation?			
http://airquality.crocker.ucdavis.edu/improve/standard-operating-procedures-sop/			
http://airquality.crocker.ucdavis.edu/improve/resources-operators/			

7. Do operators have any issues they would like to address or concerns about local activities which might affect sampling?

TSA Form Part 1 Operator Form

1. Auditor fills in top section: site location through Assessment date.
2. Auditor fills in #3 from audit constants work book info
3. Email to site operator to fill out the rest of Part 1.

http://vista.cira.colostate.edu/Improve/monitoring-site-browser/

IMPROVE
Interagency Monitoring of Protected Visual Environments
Performance Audit Worksheet VER 2.10; 2/22/2017

US Environmental Protection Agency
Office of Air and Radiation

DATE:				
LOCATION:			E Website	GPS Reading	Difference
SITE ID:		LAT:			
		LONG:			

GENERAL INFORMATION

AUDITOR INFO	
PRIMARY:	
AFFILIATION:	
SECONDARY:	
AFFILIATION:	
OBSERVER:	
AFFILIATION:	

SITE OPERATOR INFO	
PRIMARY:	
AFFILIATION:	
SECONDARY:	
AFFILIATION:	

AUDIT FILTER	
DATE:	
POS:	

**FIRST REFERENCE DEVICE	
MAKE/MODEL:	
S/N:	
Certif. Due Date:	
BACK-UP REFERENCE DEVICE	
MAKE/MODEL:	
S/N:	
Certif. Due Date:	
ALTERNATE FIRST REFERENCE DEVICE	
MAKE/MODEL:	
S/N:	
Certif. Due Date:	
ALTERNATE REFERENCE DEVICE	
MAKE/MODEL:	
S/N:	
Certif. Due Date:	

FINDINGS

Significant Findings:

General Findings:

field form I

INFORMATION

SITE CALIBRATION COEFFICIENTS

MODULE	TYPE	ELEV (f)	CALIB DATE	MAG COEFFICIENTS A	MAG COEFFICIENTS B	NOM (mV)	VAC COEFFICIENTS C	VAC COEFFICIENTS D	NOM (mV)
A									
B									
C									
D									
X (A-B-C)									
X (D)									

CONTROLLER

PRESSURE	AUDIT (mm Hg)
First Ref Std:	
Back-up Ref Std:	

TEMPERATURE AUDIT

TEMPERATURE	AUDIT (Celsius)	IMPROVE (mV)	IMPROVE (Celsius)	DIFF (Celsius)	PASS (10 degrees or less?)	FAIL
First Ref Std:						
Back-up Ref Std:						
RECALIBRATION:						

CLOCK AUDIT

TIME	AUDIT (hh:mm)	IMPROVE (hh:mm)	DIFF (min)	PASS (5 minutes or less?)	FAIL
CELL PHONE:					
RECALIBRATION:					

field form I (cont)

field form I (cont)

MODULE A

Leak Check	MaxORI	READING (mV)
	DISPLAY:	

LEAK CHECK AUDIT	
PASS	FAIL
(33 or higher?)	

REFERENCE FLOW STANDARD	MODULE (lpm)	DESIGN (lpm)
First Ref Std:		22.8
Back-up Ref Std:		22.8

FLOW AUDIT		
DIFF	PASS	FAIL
	(10% or less?)	

	ORI	READING (mV)	FLOW (lpm)
	DISPLAY:		
DISPLAY if Back-up used:			

VACUUM CALIBRATION AUDIT		
DIFF	PASS	FAIL
	(10% or less?)	

	CYC	READING (mV)	FLOW (lpm)
	DISPLAY:		
DISPLAY if Back-up used:			

MAGNEHELIC CALIBRATION AUDIT		
DIFF	PASS	FAIL
	(10% or less?)	

summary form

	TIME		TEMP		A MODULE			B MODULE			C MODULE			D MODULE	
DATE	AUDIT	IMPROVE	AUDIT	IMPROVE	AUDIT	ORI	CYC	AUDIT	ORI	CYC	AUDIT	ORI	CYC	AUDIT	ORI
1/0/1900	0	0	0		0			0			0			0	

field form II

Section 2. Sample Handling

		(O = Other) RESPONSE		
		Y	N	O
1.	Are all samples handled to avoid contamination and/or loss of material?			
2.	Observe the following handling steps for routine samples, verifying that the operator follows the sample handling SOPs correctly:			
a.	Inspection of sample prior to sampling			
b.	Installation of sample in the sampler			
c.	Retrieval from the sampler after sampling			
d.	Completion of log sheet			
3.	How do you communicate sample handling problems and to whom?			

Section 3. Monitoring Site

		(O = Other) RESPONSE		
		Y	N	O
4.	Does the operator keep the module handling area neat and clean?			
5.	Is there adequate room to perform the needed operations?			
6.	Does the sampler appear to be well maintained and free of dirt and debris, bird/animal/insect nests, excessive rust and corrosion, etc.?			
7.	Is the shelter platform (if any) clean and in good repair?			

Final Audit Checklist

1. Make sure all inlet tubes are in sampling position – tighten allen bolts on module D.
2. Make sure temperature probe is in sampling Tee correctly
3. Check that the black caps are in place
4. Take pictures of each module


C

After the Audit

Now what do you

do with your audit data??!!

Reporting and follow-up by the schedule

Auditors

- cannot officially "fail" a site. They can only make observations that the performance does not meet EPA established acceptance criteria, or the applicable QAPP.
- are not authorized to direct operators to correct problems. If the operator chooses to correct any problems, the auditor should retest and report both results on the worksheets as provided.
- document and report problems
- Email audit workbook to:
  - UC Davis: yjzhao@ucdavis.edu
  - Derek Day: derek.day@colostate.edu

Review of Critical Features of the IMPROVE TSAs

- Scheduling – UC Davis and site operators
  - Sampling schedule can be found on IMPROVE Calendar
  - http://vista.cira.colostate.edu/Improve/improve-calendars/
- Audit Instruments/Tools – use the check list
- Forms and record keeping – use the TSA workbook and cheat sheet
- Finishing audit – check sampler configuration – take photos
- Audit worksheet sent to UC Davis and me

IMPROVE Audit Issues to think about

- **Reconsider Safety issues:**
  - Heat/cold, water, first aid supplies, clothing, snacks, storms
- **Carry 2 Flow audit devices**
- **Cell Phones may not get a signal at some locations – give someone your itinerary**

Field Portion of Training

- Tomorrow, March 30, 1 PM
- Great Sand Dunes National Park